INSTRUCTION MANUAL

REGATRON

POWER SUPPLY

MODEL 2384M

SERIAL No. _____

ELECTRONIC MEASUREMENTS COMPANY, INCORPORATED

EATONTOWN · NEW JERSEY

TELEPHONE: (201) LIberty 2-0300 TWX: (201) 542-2273 CABLE: ELMEASCO

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REGATRON®
PROGRAMMABLE
POWER SUPPLY

MODEL 238A

SERIAL No. _____

ELECTRONIC
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Eatontown, New Jersey

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REGATRON PROGRAMMABLE

VOLTAGE REGULATED POWER SUPPLY

MODEL 238A

TABLE OF SPECIFICATIONS

OUTPUT
0 to 1500 volts, 0 to 100 ma.

REGULATION
Line—0.1% or 0.05 volts, whichever is greater, for line change from 105 to 125 volts ac, 50-60 cps.
Load—0.1% or 0.05 volts, whichever is greater, no load to full load.

REGULATION WITH CHOPPER STABILIZATION
Line or Load—0.01% or 0.003 volt, whichever is greater.

STABILITY—Within 0.1% or 50 millivolts, whichever is greater, for 8-hours after 30-minutes warm-up, under fixed line, load, and temperature conditions, with precision high stability external programming resistor.

STABILITY WITH CHOPPER STABILIZATION—0.05% +2 millivolts, same conditions as above.

CURRENT LIMITER—Continuously variable control, panel calibrated from 0 to 150 ma.

RIPPLE—1 millivolt RMS maximum, with positive or negative output grounded.

OUTPUT IMPEDANCE—Less than 0.01 ohm at low audio frequencies; 0.1 ohm to 10KC; 1 ohm to 40KC.

TRANSIENT RESPONSE—For step change from no load to full, or full to no load, output recovers to within dc regulation limits of initial value within 1 millisecond.

OVERVOLTAGE CAPABILITY—See paragraph 2-11.

REMOTE PROGRAMMING RESISTANCE—1000 ohms per volt of output.

REMOTE SENSING—See paragraph 2-8, 2-9.

AMBIENT TEMPERATURE RANGE—20°C to +45°C.

OUTPUT POLARITY—Positive or negative ground or floating output.

CIRCUIT PROTECTION—Contains time delay relay set for warm-up operation prior to application of dc. Input ac line fused, dc output fused.

TERMINATIONS—Front: BNC-high voltage connectors. Rear: Barrier-type terminal strips. Line cord is 3-conductor type.

CONTROLS—STEP SWITCH (selects) voltage ranges of 0, 300, 600, 900, 1200 volts; COARSE control 0-300 volts; FINE control 0-30 volts.

MOUNTING—Unit fits 19-inch standard racks and is equipped with rubber feet for table mounting. Top and bottom are protected by perforated metal covers.

FINISH—Smooth gray semi-gloss enamel Class 2 per MIL-E-15090.

DIMENSIONS—10-1/2 inches high, 16-3/4 inches deep, 19 inches wide.

WEIGHT—75 pounds, approx.

INPUT POWER REQUIRED—1155 watts.

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Addendum #117
10/31/61

INSTRUCTION MANUAL CHANGE

MODEL 238A

The preliminary instruction manual for Model 238A Regatron Programmable Power Supply omits certain references to the current limiter, which is now a standard feature of this model. These references are presented in this addendum and will be incorporated in the first revision of this manual.

Page 1. Substitute the following for paragraph 1-2:

1-2. DESCRIPTION. This unit operates on 105 to 125 volts, 50 to 60 cycles, single phase a-c. Input power and detailed performance data are presented in the Specifications Table. The unit may be table or rack-mounted in a standard 19-inch rack. Output voltages are set by means of three controls; a STEP SWITCH for selecting the basic voltage ranges of 0, 300, 600, and 1200 volts; a COARSE control additively covering 0 to 300 volts; and a FINE control additively covering 0 to 30 volts. These controls permit resolution of output voltages down to a fraction of a volt. A CURRENT LIMITER control provides adjustment of the output current to any maximum from 0 to 150 ma. Three output terminations marked + GND - are located on the front panel for local operation, and an additional set of terminations (Figure 2-2) is located behind a protective cover at the rear of the equipment for programmed operation (see Figure 2-1).

Page 3. Substitute for step c. in paragraph 2-4:

c. STEP SWITCH, COARSE, FINE and CURRENT LIMITER controls are at minimum, fully counterclockwise.

Page 4. Substitute for step c. in paragraph 2-6:

c. Adjust COARSE and FINE controls additively to reach the desired output voltage. Adjust the CURRENT LIMITER control to a setting 5 milliamperes above the required maximum current value; or, if limiting is not required, rotate the control to the 150 ma setting.

Addendum #117

Page 4. Substitute for step d. in paragraph 2-7:

d. Set STEP SWITCH, COARSE, and FINE controls to zero. Adjust CURRENT LIMITER control to a setting 5 milliamperes above the required maximum current value; or, if limiting is not required, rotate the control to the 150 ma setting.

THEORY OF OPERATION, CURRENT LIMITER

In general, the current limiter, the circuit of which includes type pnp transistor Q401, tube V401, and associated components, controls the bias on the grid of driver amplifier V107, thereby determining the maximum conduction of the series system. The setting of the CURRENT LIMITER control R404 adjusts the bias applied to the emitter of transistor Q401. The base of Q401 is connected through limiting resistor R408 to one side of resistor R6, which is in series between the negative side of the unregulated dc source and the negative output terminal. Thus the voltage across R6 is directly proportional to the current output of the power supply. When current output is less than the CURRENT LIMITER control setting, transistor Q401 does not conduct and, since the collector of Q401 provides the grid input to tube V401, the tube remains at cut-off. Under these conditions the current limiter output signal from the cathode of V401, which is impressed upon the divider consisting of glow tubes V109 and V110 and resistors R111 and R114, has no effect on the bias applied to the driver amplifier V107. When current output reaches or attempts to exceed the CURRENT LIMITER control setting, the voltage drop across resistor R6 drives the base of Q401 more negative, causing the transistor to conduct. The resulting collector current drives the grid input to V401 more positive, causing the tube to conduct. When this occurs, the V401 cathode voltage, applied at the junction of V110 and R111, exercises control over the grid input to driver amplifier V107 and thereby determines the maximum conduction of the series system, thus limiting output current to the CURRENT LIMITER control setting. Variable resistor R401 permits fine adjustment of the voltage across R6, and is used for calibration at a high current setting. Variable resistor R403 permits calibration of the CURRENT LIMITER control R404 to panel markings, and is used at a low current setting.

In Section 4, MAINTENANCE AND ADJUSTMENT, add:

REPLACEMENT OF TRANSISTOR IN CURRENT LIMITER. If transistor Q401 is replaced, recalibration of the current limiter is necessary. To recalibrate proceed as follows:

a. Connect a suitable milliameter and a dummy load in series with the output terminals.

b. Install a new transistor, turn on equipment and set CURRENT LIMITER control to 25 ma.

c. Adjust control R403 (inside equipment) to obtain a 25 ma reading on the external milliameter.

d. Set CURRENT LIMITER control to 100 ma.

e. Adjust control R401 (inside equipment) to obtain a 100 ma reading on the external milliameter.

SECTION I

INTRODUCTION AND DESCRIPTION

1-1. **INTRODUCTION.** This Regatron Programmable voltage regulated power supply is a wide-range source of voltage regulated d-c power. It is designed to supply output voltages continuously adjustable from zero volts to 1500 volts at maximum rated current over its entire range. The patented Regatron design permits this power supply to be controlled, or programmed, from a remote or local point, thereby meeting the need for remote control arising out of the increasing tendency towards automation or centralized control.

1-2. **DESCRIPTION.** This unit operates on 105 to 125 volts, 50 to 60 cycles, single phase a-c. Input power and detailed performance data is presented in the Specifications Table in front of the manual. The unit may be table or rack-mounted in a standard 19-inch rack. Operating and adjustment controls, indicators and output connections are located on the front panel. Output voltages are set by means of the three controls, a STEP SWITCH for selecting the basic voltage ranges of 0, 300, 600, 900 and 1200 volts; a COARSE control for covering the in-between range of 0 to 300 volts and a FINE control for covering the range of 0 to 30 volts. The controls are additive and permit precise selection of output voltages down to a fraction of a volt. There are three output terminations marked + GND - located on the front panel for local operation, and an additional set of terminations (figure 2-2) is located behind a protective cover at the rear of the equipment for programming of the equipment (see figure 2-1).

1-3. **PROGRAMMING.** The output voltage of this power supply can be controlled remotely, or programmed, with a low power resistor connected to the REM and "+" output terminals. Output voltage then depends directly on the value of the programming resistor in the ratio of 1 volt per 1000 ohms. This relationship remains constant over the entire output voltage range, even at a fraction of a volt. In programmed operation, regulation and stability are maintained within specified ratings. See paragraph 2-8 for instructions on programmed operation.

1-4. **OVERVOLTAGE.** Voltage output greater than the specified maximum is available at reduced output current. See paragraph 2-11 for instructions on overvoltage operation.

1-5. **CONSTANT-CURRENT OUTPUT.** This unit can be converted from constant-voltage to constant-current output by means of a simple external connection. See paragraph 2-14.

1-6. **CHOPPER STABILIZATION.** For units originally supplied without chopper stabilization, a conversion kit is available to incorporate this feature, or the unit may be returned to the factory for conversion.

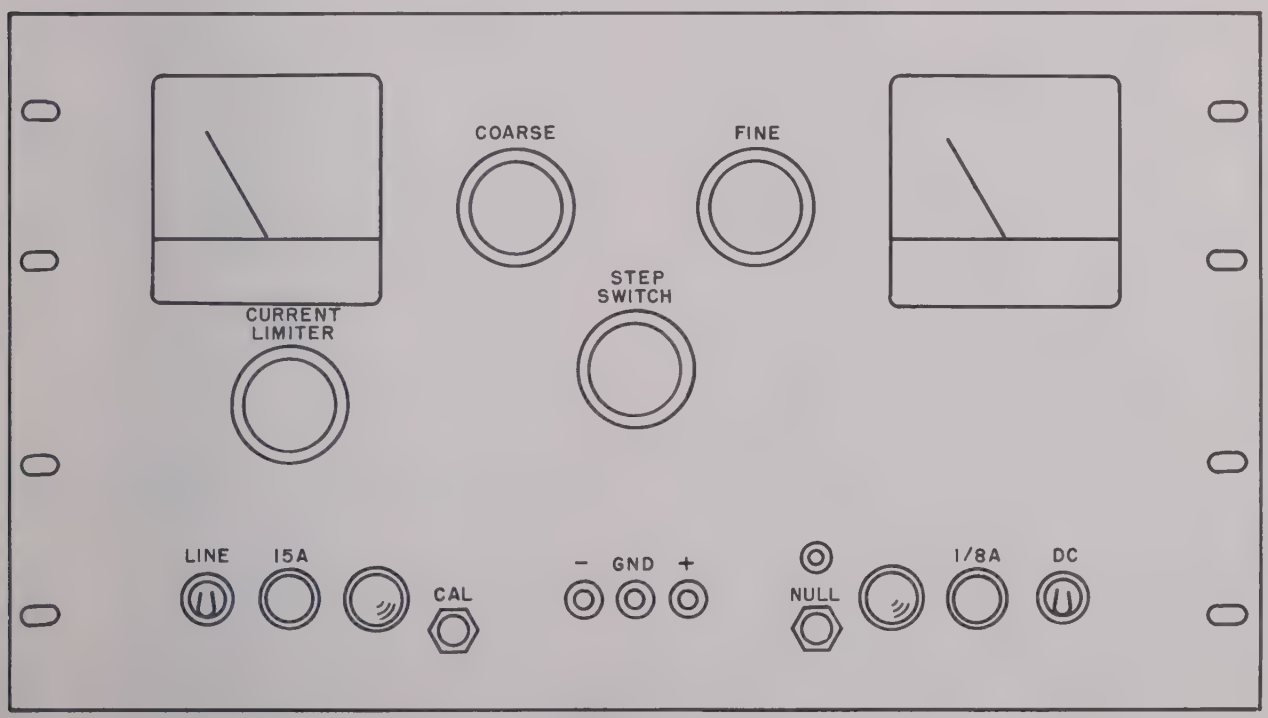


Figure 1-1. Regatron Programmable Voltage Regulated Power Supply

SECTION 2

INSTALLATION AND OPERATION

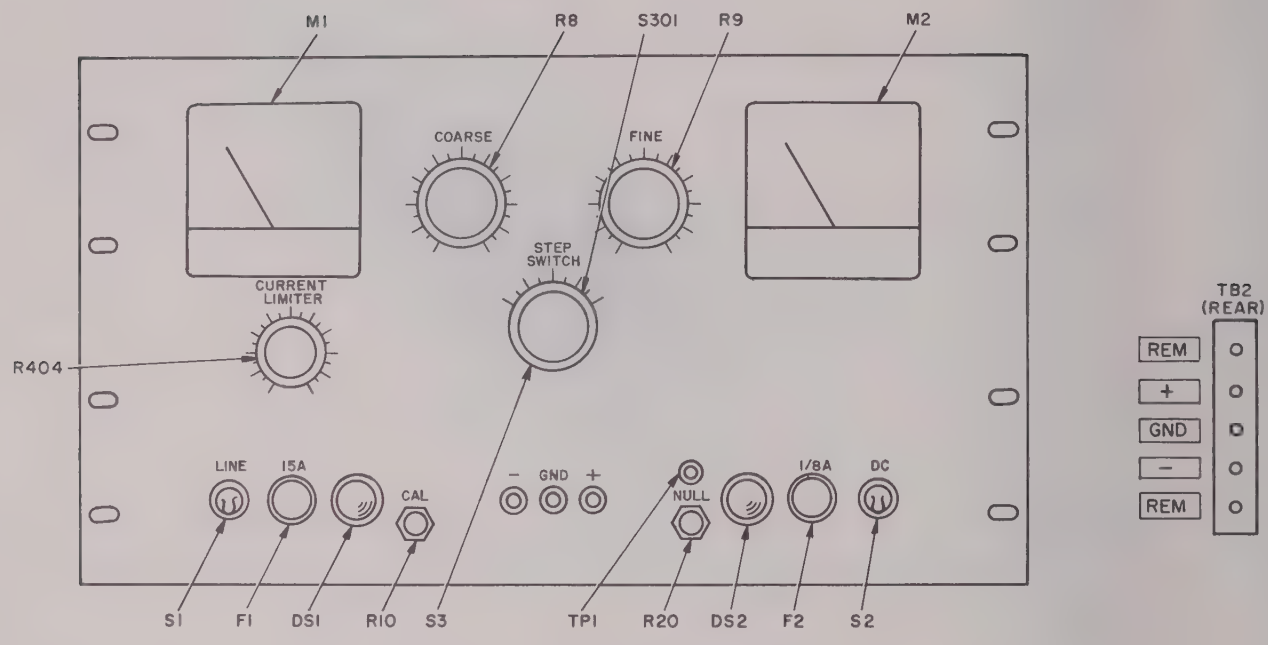


Figure 2-1. Controls and Terminations

> WARNING
>
> Lethal voltages exist at all terminations and in the interior of this power supply. Extreme care should be exercised at all times. Be sure to disconnect the power cord and ground the negative terminal before making any adjustments.

2-1. INSTALLATION. This unit operates on 105 to 125 volts, 50 to 60 cycles, single-phase ac. Input power required is stated in the Specifications Table. The equipment may be table or rack-mounted in a standard 19-inch rack. The rubber mounting feet may be removed from the bottom cover if they interfere with other rack-mounted equipment. Sufficient clearance should be allowed above and below the unit to provide adequate ventilation. The top dust-cover may be removed, if desired, to increase the ventilation.

2-2. CONTROLS AND TERMINATIONS. (See Figure 2-1). Haphazard operation or improper setting of the controls can cause damage to the equipment. For this reason, it is important to know the function of every control and termination. Table 2-1 lists the various controls and terminations for this equipment.

2-3. REAR TERMINATIONS. (See Figure 2-2.) All connections for local or remote operation can be made at the terminal board TB2 located at the rear of this power supply, behind a removable back panel. This terminal board contains five terminations marked REM + GND - REM. The equipment is normally set for local operation as shown in figure 2-2. For remote programmed operation refer to paragraph 2-8. Load connections can be made to the front panel terminals as well as the terminal board.

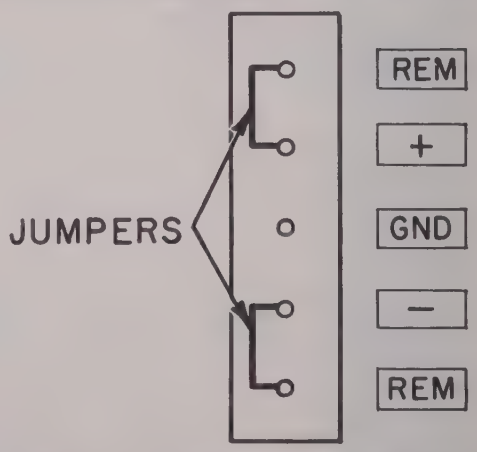


Figure 2-2. Rear Terminal Board TB2 in Local Operation

TABLE 2-1. FRONT PANEL CONTROL AND TERMINATION

CONTROL	FUNCTION
LINE switch S1	Controls a-c line input and activates TDR relay K1, disconnects DC switch S2 until after warm-up.
DC switch S2	Controls regulated d-c output.
STEP SWITCH S301	For selection of basic output voltages calibrated to dial markings on panel 0, 300, 600, 900, 1200.
COARSE control R8	For additive adjustment of voltages from 0 to 300 volts calibrated to dial markings.
FINE control R9	For additive adjustment of voltages from 0 to 30 volts calibrated to dial markings.
CAL adjustment R10	For screwdriver adjustment of output voltage to panel markings or for calibration to exact 1000 ohms per volt programmed operation (see paragraph 4-4).
NULL adjustment R20	For screwdriver adjustment for zeroing of balanced input detector (V108) (see paragraph 4-2).
- GND + binding posts	For connection of load.
TP1 Black Test Jack	For making connection during NULL adjustment (see paragraph 4-2).
DC Milliammeter M1	Range 0 to 100 ma.
DC Voltmeter M2	Range 0 to 1500 V. Voltmeter may be overloaded during overvoltage operation without damage.
CURRENT LIMITER control R404	For adjustment of current output to desired maximum value for load.
DS1 Lamp	White lamp indicates a-c power is ON when LINE switch is closed.
DS2 Lamp	Red lamp indicates d-c power is ON when DC switch is closed.
F1 Fuse	15 amp in a-c line input circuit.
F2 Fuse	1/8 amp in "+" d-c circuit, protects against short circuit or overload across output. With CURRENT LIMITER a larger fuse may be used.

2-4. PRELIMINARY. Before connecting to a-c power, check the following:

a. LINE switch is OFF (down).

b. DC switch is OFF (down).

c. STEP SWITCH, COARSE, and FINE controls are at minimum, fully counterclockwise.

d. Terminal Board TB2 is connected for local operation as shown in figure 2-2.

e. GND terminal is connected to correct polarity output terminal or disconnected for floating output.

2-5. LINE AND LOAD CONNECTIONS.

a. Connect load to "+" and "—" output posts. It should be noted that the regulation of this unit is measured at the output posts. To maintain the specified regulation in actual service, the load wires must be heavy enough to prevent substantial voltage drops between the output posts and the load. Load can also be connected to rear terminations (see paragraph 2-3).

b. Connect line cord to a-c power outlet.

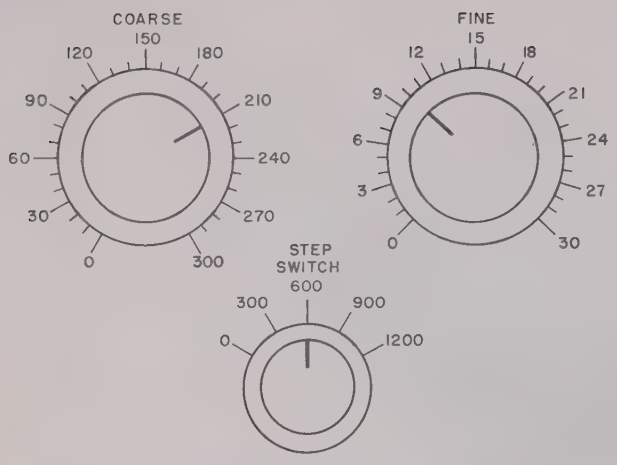


Figure 2-3. Setting of Output Voltage Controls

2-6. LOCAL OPERATION.

a. Throw LINE switch to ON: clear indicator should light.

b. Set STEP SWITCH to nearest voltage below desired value. See Figure 2-3. For example, if 820 volts is the required output voltage, set STEP SWITCH to 600.

c. Adjust COARSE and FINE controls additively to reach the desired output voltage.

d. Throw DC switch to ON. The DC ON red indicator will light. (See Note).

NOTE

A time delay relay K1 controls the warm-up time for this equipment thus preventing excess voltages to load during warm-up. Subsequently, the DC switch can be thrown on or off with no danger of exceeding the desired output voltage.

2-7. REMOTE SENSING, LOCAL. For remote sensing in local operation, disconnect jumper wires shown in figure 2-2, connect a lead from "+" REM post out to the "+" termination on the load, and from "—" REM post out to the "—" termination on the load, and proceed as in paragraph 2-6.

2-8. PROGRAMMED OPERATION. As stated in paragraph 1-2, the output of this power supply can be remotely controlled, or programmed, with a resistor. For programmed operation, proceed as follows:

a. Throw DC and LINE switches off and disconnect line cord.

b. Disconnect jumper wires from terminal board (see figure 2-2).

c. Connect the load and programming resistor as shown in figure 2-4A. Output voltage depends on programming resistance in the ratio 1: 1,000. For example, to obtain 50 volts, use a 50,000 ohm resistor.

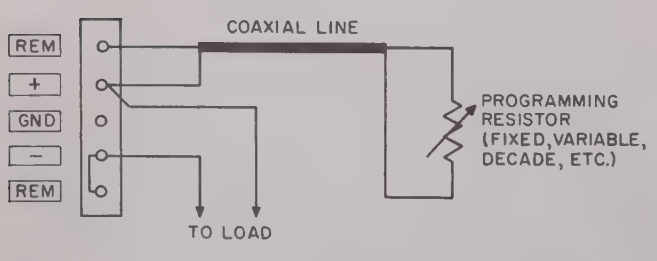
d. Set STEP SWITCH, COARSE and FINE control to zero.

e. Throw LINE and DC switch on. Programmed voltage is now applied to load.

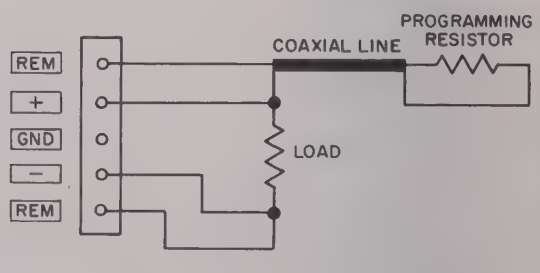
Unless the programming resistor itself is physically shunted across the REM and "+" terminal posts, it is desirable to use shielded or coaxial cable, as shown in figure 2-4A, to prevent injection of ripple and noise from external sources. An insulated cable such as RG 58/U is recommended because of the fact that the coaxial sheath carries output potential.

For long-term or permanent programmed operation it is advisable to short out the internal controls. This will eliminate possible disturbance of programmed voltage by accidental rotation or vibration of the STEP SWITCH, COARSE or FINE controls, and will yield, in general, greater stability.

Programmed operation can be combined with use of the internal controls, when convenient or necessary, merely by omitting step d of paragraph 2-8, and adjusting controls to any desired value. In this case the value of the programming resistor will be added to the values to which the internal controls are adjusted, and the total resistance will determine output voltage.



A. LOCAL SENSING



B. REMOTE SENSING

Figure 2-4. Programmed Operation

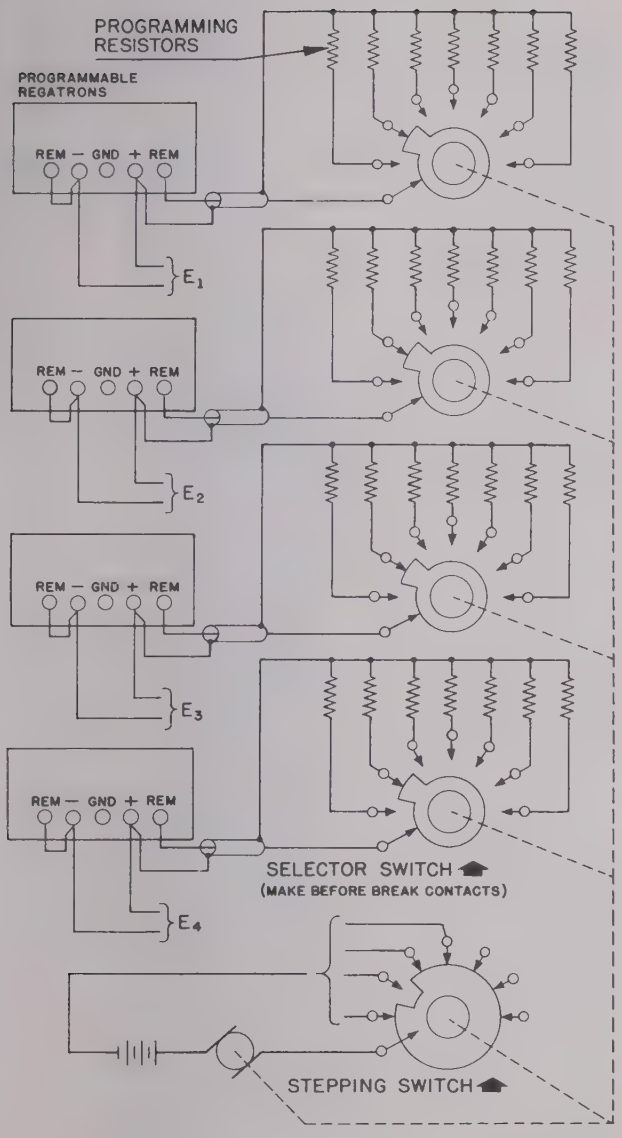


Figure 2-5. Programming with Stepper Switch, Each Level Controls one Regatron Power Supply

2-9. REMOTE SENSING, PROGRAMMED. Where load and control resistor are far from the unit but near each other, the method of figure 2-4B will eliminate the effect of voltage drops in the output leads, yielding remote sensing for regulation at the load.

2-10. PROGRAMMING SUGGESTIONS. Although the above programming instructions are illustrated with a single, fixed resistor as the remote control, it is evident that variable resistors, driven potentiometers, or fixed resistors wired to stepping switches can be employed to deliver voltages in a wide variety of time/amplitude patterns.

The time required for switching from one programmed voltage to another varies from the seconds range to the milliseconds range, depending upon conditions. Modifications for special switching times are available on special order from the factory.

It is also evident that programming can be manually or automatically actuated. As an example of automatic programming, figure 2-5 illustrates a four-level rotary stepper switch, each level of which controls one Regatron supply. As shown, the entire battery can be stepped through a sequence of four programmed outputs upon command.

In an extensive system, a central board may contain the switches or rheostats for the programming of several Regatron power supplies in different locations. In such a system it is practical to calibrate the control elements directly to dial markings, remembering that the accuracy of calibration depends upon the accuracy of the resistances and/or the dial markings.

2-11. OVERVOLTAGE OPERATION. This power supply is capable of voltage output higher than the specified maximum, at reduced output current. For overvoltage, an external programming resistor must be employed to substitute for or add to the resistance of the STEP SWITCH, COARSE and FINE control in order to extend the control resistance range and, therefore, the output range. Figure 2-6 illustrates the current derating encountered in overvoltage operation.

2-12. REFERENCE AGING. The voltage reference tube employed in this power supply exhibits progressive change of voltage with aging, typically, 0.5% for 1000 hours of use. The resulting error at the output remains at a constant percentage throughout the voltage range of the power supply, but the absolute error varies directly with the output setting. Periodic calibration by the method described in paragraph 4-4 may be performed to eliminate any error due to aging of the reference tube.

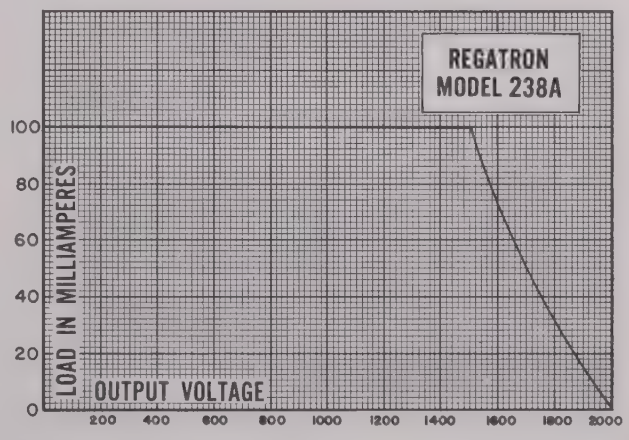


Figure 2-6. Overvoltage Operation, Showing Current Derating Curve

2-13. USE AS VOLTAGE STANDARD. If a precision decade box is available for use as a remote programming control this power supply will serve as a voltage standard, the accuracy of which (neglecting aging of the reference) will be slightly poorer than that of the decade box, even for a decade accuracy of 0.1%.

With the decade box connected as the remote programming resistor, output voltage will be indicated directly by the decade dials. Thus, the thousand-ohm-per-step dial indicates volts, the 10,000-per-step dial indicates tens of volts, and 100,000-per-step dial indicates hundreds of volts.

In voltage-standard use the power supply should be calibrated as described in paragraphs 4-7 and 4-8. Error due to aging of the internal reference can be nullified by periodic recalibration.

2-14. CONVERSION TO CONSTANT-CURRENT OUTPUT. For conversion from constant-voltage to constant-current output, proceed as follows:

a. Select a sample resistor, R_S in figure 2-6 above, which will carry the load current and develop a sample voltage for the control system. To determine its value, select a sample voltage. Five to 10 volts is a good range. Although the voltage may be made as high as desired it must be remembered that the sample voltage subtracts from the available output voltage. If E_S is the sample voltage and I_L is the desired load current, then $R_S = E_S/I_L$, where R_S is in ohms and I_L is in amperes. The actual wattage will be $E_S \times I_L$. The resistor used should have a somewhat higher wattage rating.

b. Disconnect jumper wires from "+" and REM on TB2 (see figure 2-2).

c. Make connections as shown in figure 2-6 and set both panel controls to zero.

d. Throw the LINE switch ON.

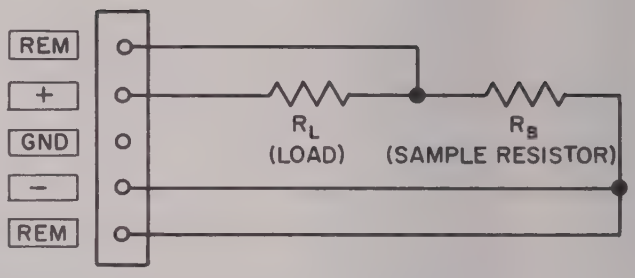


Figure 2-7. Conversion to Constant-Current Output

e. Bring current up to the desired value by turning the FINE control only up to the voltage selected as the sample in step a above. In constant-current operation the FINE control is the output control (for sample voltages up to 10 volts).

The conversion described above provides good d-c regulation. The a-c impedance of the power supply, however, is relatively low, and this should be noted in considering applications.

2-15. CHOPPER STABILIZED OPERATION. As stated in the Specifications Table, this unit achieves regulation of 0.01% or 3 mv, and stability of 0.05% + 2 mv for 8-hours when equipped with chopper stabilization. Although both ratings are conservative, note that the stability figure is specified with the unit in programmed operation, using an external resistor of high electrical and (in the case of a variable resistor) high mechanical stability. This rating can be realized only in such operation, and with the internal controls shorted out or set to zero to prevent them from contributing variations resulting from accidental rotation or vibration.

SECTION 3

THEORY OF OPERATION

3-1. GENERAL. This power supply employs a full-wave rectifier, the positive output of which is applied to series amplifiers controlled by the regulator loop. The resulting regulated d-c voltage constitutes the output.

3-2. CONTROL SYSTEM, LOCAL AND PROGRAMMED. Figure 3-1 illustrates the output control configuration in simplified form. If input G_1 and G_2 are equal ($E_D = 0$) then:

$$\frac{E_O}{E_R} = \frac{R_1}{R_2} \text{ and } E_O = E_R \times \frac{R_1}{R_2}$$

where E_O = regulated output voltage
E_R = internal reference voltage
and R_2 is a fixed resistor.

Since E_R and R_2 are constant, $E_O = KR_1$; or, the output voltage is dependent only upon the value of R_1 which, in local operation of the power supply, consists of the STEP SWITCH, COARSE and FINE control. In programmed operation, R_1 is the remote programming resistor. In either local or programmed operation, the voltage output = $0.001R_1$, or, 1,000 ohms control resistance per-volt output. In practice, R_2 can be adjusted with the CAL control (on the panel) for exact 1,000 ohms-per-volt programmed operation, or to calibrate output with panel dial markings.

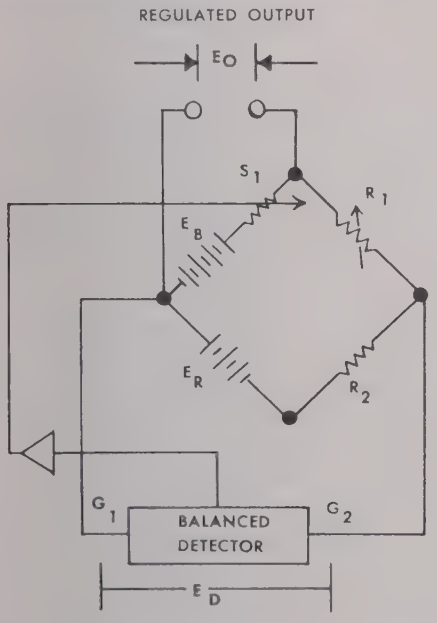


Figure 3-1. Output Control Configuration

3-3. UNREGULATED DC SUPPLY. A time delay relay K1 inserted in the primary input circuit of the unregulated d-c supply automatically controls warm-up time for this equipment when the LINE switch is thrown, thus preventing excess voltages to the load during warm-up time. Subsequently the DC switch can be ON or OFF with no danger of exceeding the desired output voltage. The main d-c supply employs fourteen silicon diodes in a full-wave rectifier bridge, with filtering provided by five 120 UF electrolytic capacitors, C1 through C5 in series and five 82K bleeder resistors, R1 through R5 which draw approximately 2 ma, and which discharge C1 through C5 upon turn-off of the power supply. Four rectifiers in a full-wave bridge CR2a, CR2b, CR2c, CR2d, comprise the 270 volt screen supply for series amplifiers V201 through V212, with filtering by a 120 UF electrolytic capacitor C6. This screen supply, the negative of which is returned directly to the cathodes of the series amplifiers, also serves as plate supply for the cathode follower V106 and for the driver amplifier V107. Rectifiers CR3a and CR3b, with capacitor C7 as filter, are the source of positive service voltages for tubes V101, V102 and V108. Rectifiers CR3c and CR3d, with capacitor C8 as filter, are the source of negative service voltages for tubes V103, V104 and V105.

3-4. REGULATOR SYSTEM, GENERAL. The regulator system figure 3-2 employs a balanced input detector V108, connected from the zero point of the input bleeder to the negative reference point (-REM) to detect departures from balance. The amplifier error is applied to a high gain amplifier V107, which drives the grids of the series amplifiers V201 through V212 through cathode follower V106 in such a manner as to overcome the error. Because of the high gain of the system, the error at equilibrium is very small. V/r tubes V101 and V102 maintain a steady positive potential for the tubes of the regulator system. V/r tubes V103 and V104 maintain the steady negative potentials for the tubes of the regulator system and act as a pre-regulator for V105, which is the source of stable reference potential for the bridge circuit.

3-5. BIAS AND OPERATING POTENTIAL SUPPLIES. The +150 volts across V101 is dropped to +108 volts by resistor R101, further regulated by V102 for use on the plates of the balanced amplifier V108 and the tube in chopper-stabilizer unit. The -150 volts across V103 is similarly dropped to -108 volts by resistor R112, further regulated by V104, and utilized for the cathodes of V108 and the negative end of the voltage divider network composed of V108, V110 and R114 and R111. A one megohm resistor R107 applies a momentary, high firing potential to v/r tube V104; this drops to -108 volts when the tube begins to conduct. A type 1N34 diode, CR102, functions as a one-way switch. CR16 disconnects V104 from the junction of R112 and R113 to permit momentary application of the high firing potential through R107. As soon as V104 has fired, CR102 closes the path from the junction of R112, permitting normal flow through V104 and removing the momentary firing potential. Resistor R108 drops the -108 volts to -85 volts for use in reference tube V105.

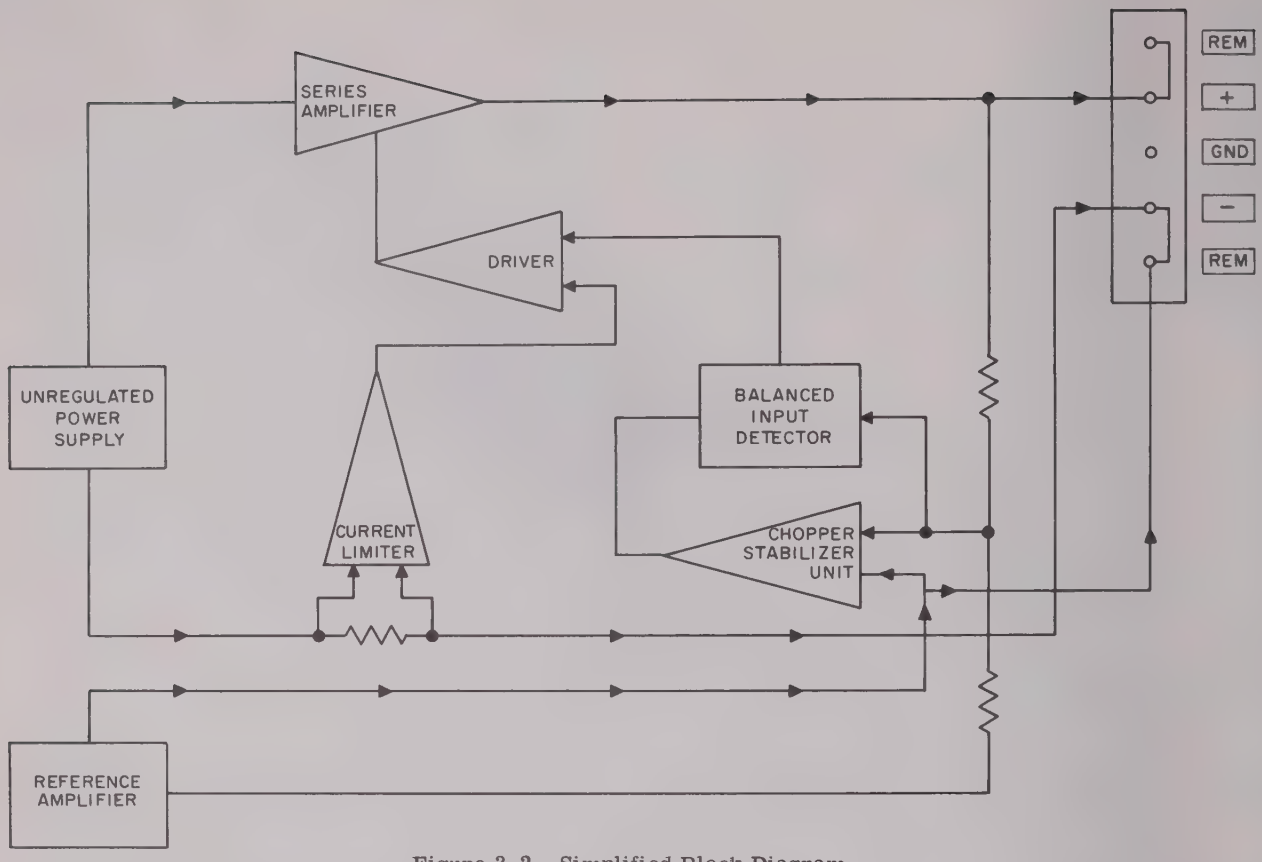


Figure 3-2. Simplified Block Diagram

3-6. REFERENCE. The internal reference potential for the power supply, also employed as a regulated service potential for the cathode of V107, is obtained across tube V105, the gas filled reference tube which maintains a very stable drop of approximately -85 volts. CAL control R10 permits calibration of the control system to a precise output voltage based upon the exact potential across V105 and permits periodic recalibration to eliminate error resulting from aging of V105.

3-7. SERIES AMPLIFIERS. Twelve parallelled type 6L6 beam power pentodes V201 through V212 are employed as series elements, or variable conductances. Control grids are coupled through cathode follower V106 to the plate of the driver amplifier V107. The cathodes of V201 through V212, from which positive, regulated output voltage is obtained, are removed from the "+" output terminal when DC switch S2 is thrown off (see paragraph 3-11).

3-8. BALANCED INPUT DETECTOR. A cathode-coupled amplifier V108 is used as an input detector, grid 7 of which is effectively at the positive of the reference potential, and grid 2 at the other null point on the opposite side of the control bridge. Regulated plate supply is taken from V102, and cathodes are returned through R115 to -108 volts regulated by V104. The NULL control R20 permits setting of the balanced input detector to zero difference between grids; capacitor C15 feeds any a-c components of the output voltage directly into the amplifier, thereby increasing the a-c gain and giving improved transient and ripple performance. Output from plate 6 of V108 is applied across a coupling and voltage divider network consisting of glow discharge regulator tubes V109 and V110 and resistors R110, R111, and R114 and capacitor C102. The glow tubes couple plate potential to the grid of V107, maintaining a constant voltage drop which permits the grid to follow the potential at the plate of V108, thus constituting an effective d-c coupling which avoids any substantial loss of gain.

3-9. DRIVER AMPLIFIER. This stage employs a pentode, V107, in high gain, low current "starved" operation. The output is coupled through cathode follower V106 to the control grids of the series amplifiers, completing the regulator system loop.

3-10. CHOPPER-STABILIZATION. The chopper stabilizer is installed across the grids of the balanced input detector. Without chopper-stabilization this stage is subject to drift, with the result that output voltage may change up to .1% or 50 millivolts for 8-hours.

The stabilizer unit, utilizing a contact modulator (chopper), continually samples the offset at grid 2 of V108, rectifies and filters it, and applies the resulting correction signal via reference grid 2 (removed from minus in chopper-stabilized version) to the regulator system to reduce the net offset to a vanishingly small value. The chopper-stabilizer adds a gain of approximately 1,000 to the regulator, with the result that regulation, as well as stability, improves to the figures shown in the Specification Table.

3-11. OUTPUT CIRCUITRY. Connected across the output terminals is relay K2 which is the DC off-on control actuated by S2. In the off position one set of form C contacts shorts the controls for an output of 0 volts. The other set of contacts connects the "—" to "+" through two 25 ohm resistors R11 and R12; this serves to discharge the bank of capacitors C201 through C205 when changing voltages. Also across the output is a diode CR4, which protects the external load by presenting a low impedance to any reverse voltage which may develop when the unit is shut off. Two type ARG4 tubes V111 and V112 serve as a clamp to protect the internal reference, V105, from voltage surges when the power supply is switched from a high to a low voltage. Tubes V111 and V112 fire momentarily but are otherwise normally inoperative.

It should be noted that changing from programmed to local connections removes the positive side of the reference from the minus side of the high voltage. These connections must be re-established via the connections shown in figure 2-2.

SECTION 4

MAINTENANCE AND ADJUSTMENT

4-1. PARTS REPLACEMENT. An electrical parts list accompanies the schematic diagram in this manual along with parts location illustrations. The replacements of parts in general are completely defined by the values and tolerances indicated on the parts list. Special attention should be given to the following:

a. Replacement of any components on the printed circuit board (Reference and Amplifier Section of this power supply) could effect the NULL balance and CALIBRATION adjustment. Readjustment of these controls is recommended after parts replacement.

b. COARSE and FINE controls—If either of these wirewound potentiometers is defective, it is advisable to obtain an exact replacement. If none is available locally, an order should be addressed to the factory. Any temporary substitute potentiometer should provide an arc of 200° effective rotation for the COARSE and 270° for the FINE control for the panel dial markings to represent output correctly.

WARNING

Be sure to disconnect the line cord and ground the negative terminal on this supply to an external source before making any adjustments.

4-2. NULL ADJUSTMENT. The NULL control, located on the front panel, permits adjustment of the balanced input detector to null, or zero level. This adjustment, which holds over the entire operating range, is made as follows:

a. Remove the acorn nut covering the control.

b. With STEP SWITCH, COARSE, and FINE controls at zero, throw LINE and DC switch to ON. (The DC switch is not effective until time delay relay K1 operates).

c. Connect the negative terminal of a voltmeter to the negative output "—" post and the positive terminal of the voltmeter to TP1 test point. Use 3 volt dc scale or lower.

d. Adjust the NULL control for zero on the meter. A very sensitive indication can be obtained by alternately connecting and disconnecting the meter lead from TP1.

4-3. NULL ADJUSTMENT FOR CHOPPER-STABILIZED UNITS.

a. With unit set for zero output connect a 100 millivolt meter across the output "—" and TP1.

b. Rotate the NULL control to maximum in one direction and read the output in millivolts. Rotate NULL control to maximum in the opposite direction and read the output in millivolts. The difference between the two extremes should be less than 3 millivolts.

c. Rotate control to approximate center of range. When adjusted as described above the zero offset of the power supply should not exceed 2 millivolt. Usually, if this occurs, it is due to excessive grid current in V108. This tube should be changed and one substituted which provides less than the specified offset.

4-4. CALIBRATION. The CAL control, also found on the front panel, requires adjustment for any one of three reasons:

a. For close agreement between panel marking and output.

b. For exact 1,000 ohms-per-volt ratio in programmed output.

c. For recalibration to either of the above after replacement of V105.

This adjustment can be performed in either of two ways:

(1) Using an external voltmeter.

(2) Using an external precise source of voltage.

4-5. CALIBRATION [redacted] USING EXTERNAL VOLTMETER (Figure 4-1A.)

a. Remove acorn nut covering CAL control.

b. Turn STEP SWITCH and FINE controls to zero, set COARSE control to 300. Throw LINE, then DC switch on and adjust CAL control for 300 volt reading on the external voltmeter.

4-6. CALIBRATION [redacted] FOR EXACT 1000 OHMS-PER-VOLT PROGRAMMED OUTPUT USING EXTERNAL VOLTMETER. (Figure 4-1B.)

a. Perform step a, paragraph 4-5.

b. Turn STEP SWITCH, COARSE and FINE control to zero. Set up for programmed operation with a 300K resistor, and adjust CAL control for 300 volts on the external voltmeter.

4-7. CALIBRATION [redacted] USING AN EXTERNAL PRECISE VOLTAGE SOURCE. (Figure 4-1C.)

a. Perform step a, paragraph 4-5.

b. Connect the negative outputs of the unit and the external voltage source together.

c. Connect a voltmeter between the positive terminals of the Regatron unit and the external source.

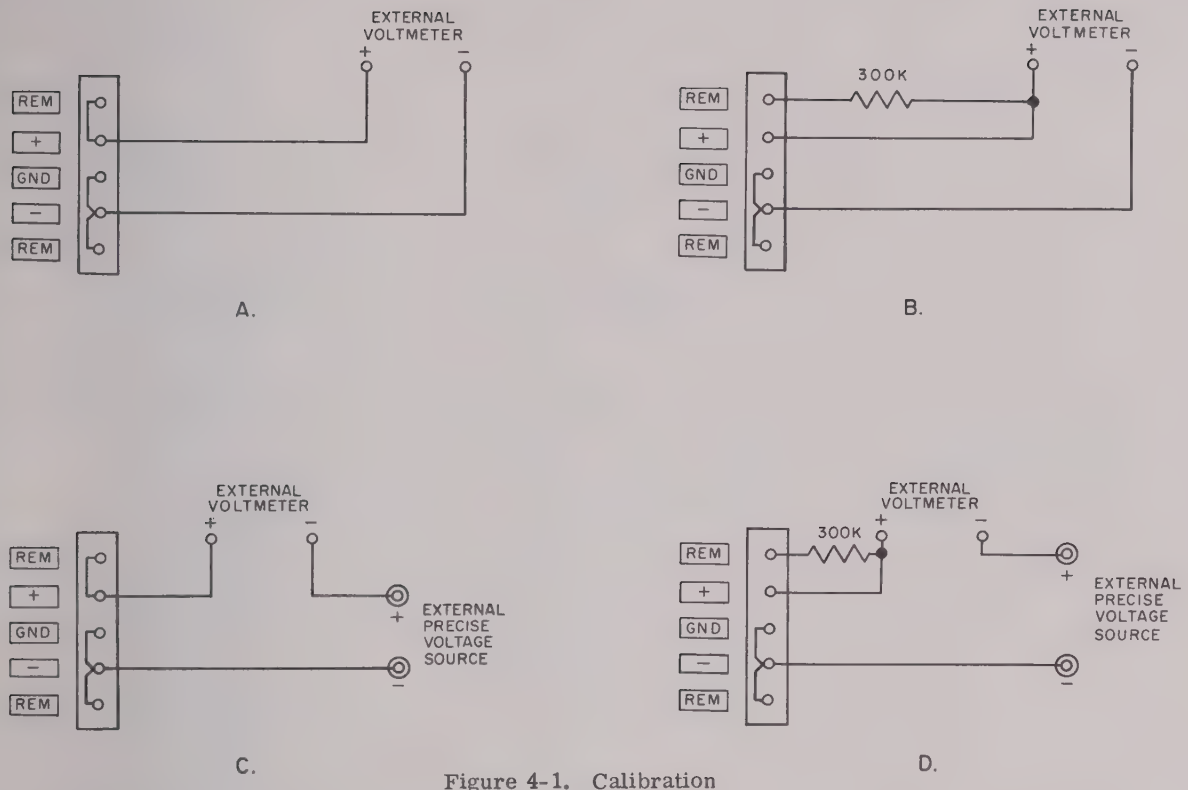


Figure 4-1. Calibration

d. Set the external source to exactly 300 volts.

e. Turn STEP SWITCH and FINE control to zero, set COARSE control to 300. Throw LINE, and DC switches on, and adjust CAL control for a zero reading on the external voltmeter. Use the lowest dc meter range available.

4-8. CALIBRATION [redacted] FOR EXACT 1000 OHMS-PER-VOLT PROGRAMMED OUTPUT USING AN EXTERNAL PRECISE VOLTAGE SOURCE. (Figure 4-1D.)

a. Perform step a, paragraph 4-5.

b. Turn STEP SWITCH, FINE and COARSE controls to zero. Program with a 300K resistor. Throw LINE and DC switches on, and adjust CAL control for zero on the external meter.

4-9. SERIES TUBE FAULTS. In selecting replacement series tubes, or when a malfunction appears to result from a faulty series tube, the following procedure is recommended:

a. Remove all series tubes but one.

b. Turn on unit, apply 1/N of full load current at a low voltage, where N = number of series tubes.

c. Check ripple and regulation.

d. Remove this series tube, place another series tube in another socket, and repeat steps b and c. Repeat steps b and c for every other socket and tube, taking one at a time.

e. If one or more series circuits test faulty, repeat the test in each case with a tube known to be satisfactory. If the repeated test proves favorable it may be assumed that the previous tube is defective. Otherwise the associated circuit should be checked for faults.

4-10. CLEANING AND LUBRICATION. This power supply employs forced air cooling. After extended service, therefore, considerable dust will be deposited on most surfaces within the unit. About twice a year the cover should be removed and all parts, particularly the fan blades, should be cleansed free of dust and grime. Lubricate the fan motor once or twice a year by squeezing a few drops of light machine oil into the lubrication holes of the bearing straps.

4-11. TABLE OF RESISTANCES. The following table applies to this unit in both standard and chopper-stabilized versions. Values in the table are nominal and may vary as much as 20% among production units without causing difficulties. Conditions of measurement:

a. A-c line cord not connected to power.

b. No load connected.

c. LINE switch off. Chassis ground floating.

d. Position STEP SWITCH, COARSE and FINE controls at 0.

e. Readings from indicated tube pins to minus output post.

RESISTANCES

DATA NOT AVAILABLE AT TIME OF PUBLICATION

4-12. TABLE OF VOLTAGES. The values in the Table of Voltages below are nominal and may vary as much as 20% among production units without causing difficulties. The measurements were made with a 100,000 ohms-per-volt meter, under the following conditions:

a. Line input 115 volts ac. LINE and DC switches on.

b. STEP SWITCH, COARSE and FINE control at zero.

c. No load connected.

d. Chassis ground floating.

e. Readings from indicated tube pins to minus post.

VOLTAGES

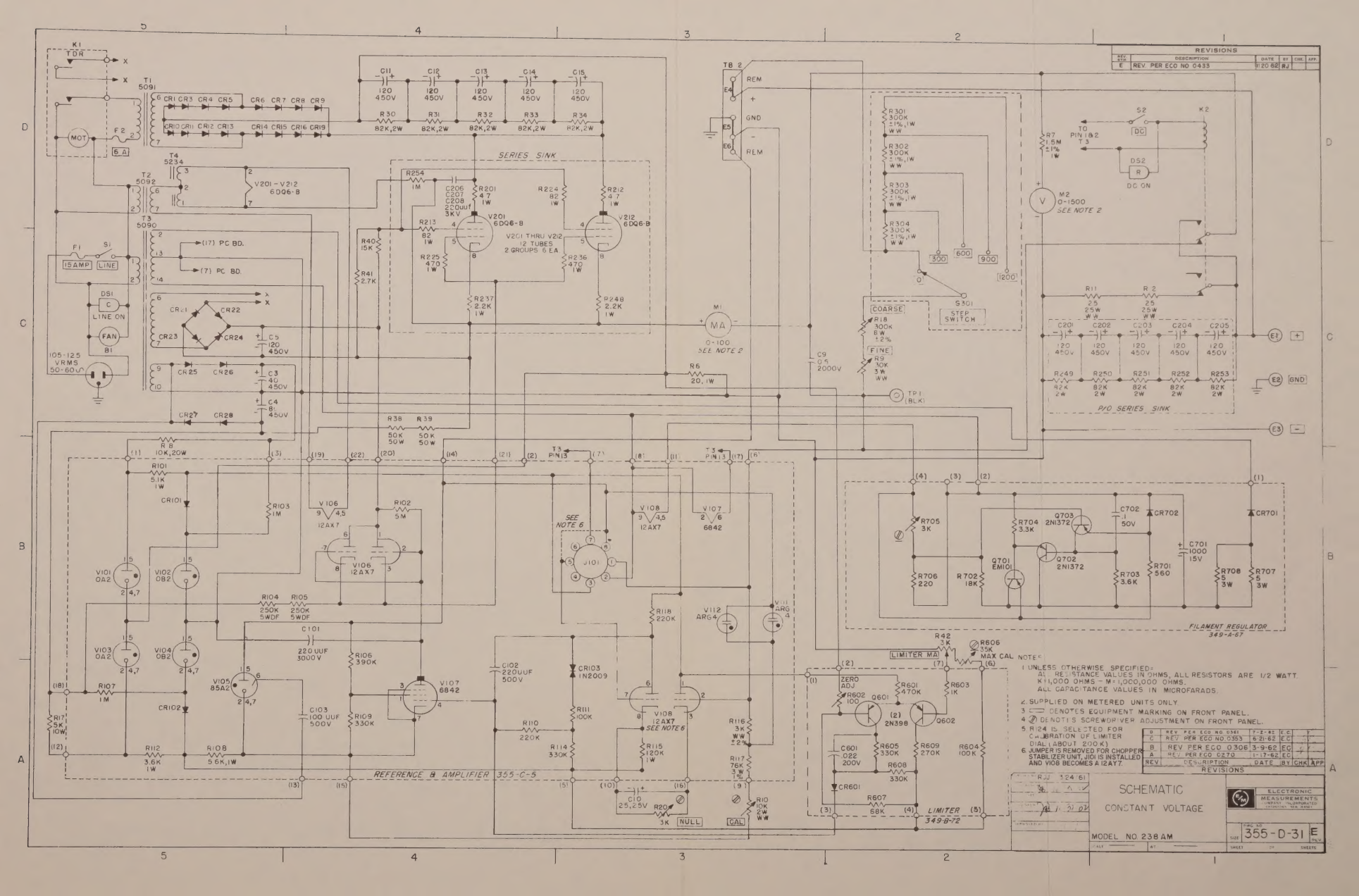
All voltages are dc unless noted.

DATA NOT AVAILABLE AT TIME OF PUBLICATION

4-13. TROUBLE-SHOOTING TABLE. Referenced below are several possible symptoms of troubles which can develop, with their most likely causes, and remedies. This table is intended to serve as a brief guide in trouble shooting.

SYMPTOM	CAUSE	
1. Unit is dead when LINE switch is thrown on.	a. Fuse F1 blown.	a. Replace with 15 amp fuse.
	b. Fuse F1 open, defective.	b. Check F1 for continuity and replace if necessary.
	c. TDR relay K1 defective.	c. Check K1 for continuity and replace if necessary.
2. Fuse F1 blows repeatedly.	a. Shorted rectifiers.	a. Check all rectifiers and replace defective one.
3. No voltage when DC switch is thrown.	a. Short circuit load.	a. Check load.
	b. Overload, above 1/8 AMP.	b. Check load.

	SYMPTOM		CAUSE		REMEDY
3.	(Contd)	c.	Fuse F2 open, defective.	c.	Check F2 for continuity and replace if necessary.
		d.	With load connected, STEP SWITCH incorrectly set, COARSE or FINE potentiometer is open.	d.	Check STEP SWITCH setting and correct. Check R8, R9 for resistance. See paragraph 4-1.
		e.	With load connected, external control line open.	e.	Check external control line.
		f.	Diode CR4 shorted (across output terminals).	f.	Replace.
		g.	Relay K2 defective.	g.	Check K2 for continuity of coil.
		h.	Current limiter set to high.	h.	Replace if necessary.
4.	No control of output, voltmeter pins at top of scale.	a.	6L6 series amplifier (V201 through V212) shorted.	a.	Replace. See paragraph 4-9e. Also check screen and cathode resistors of affected series stage.
		b.	6AU6 amplifier V107, inoperative.	b.	Replace.
		c.	COARSE or FINE potentiometer open.	c.	Check R8, R9 for resistance. See paragraph 4-1.
		d.	In remote (REM) programmed operation, external control resistor open.	d.	Check external control resistor.
5.	No control of output, voltmeter at zero, fuse F2 not blown.	a.	6L6 series amplifier (V201 through V212) defective.	a.	Replace. See paragraph 4-1.
		b.	12AY7 difference amplifier, V108 defective.	b.	Replace.
		c.	Ballast tube RT1 defective.	c.	Replace.
6.	Voltmeter indication disagrees with control settings at full acale.			a.	Recalibration necessary.
7.	Output voltage lower than control setting but recalibration impossible or out of CAL range.	a.	85A2 reference tube V105 shifted voltage.	a.	Replace. See paragraph 4-1. Also recalibrate.
		b.	OA2, V103, defective.	b.	Replace.
8.	Output voltage lower than control setting in chopper stabilized unit.	a.	Tube V1 (12AX7) in chopper-stabilizer unit defective.	a.	Replace.
9.	Poor line regulation.	a.	Defective V101, V102, V103, V104, V105, or V108.	a.	Replace. See paragraph 4-1.
		b.	Defective rectifiers.	b.	Check and replace.
10.	Poor load regulation.	a.	Poor load connections or high resistance in load leads.	a.	Check load connections.
		b.	6L6 series amplifier (V201 through V212) defective.	b.	Replace. See paragraph 4-9.
		c.	Chopper inoperative.	c.	Replace chopper.
11.	Excessive zero-offset (drift) in chopper-stabilized unit.	a.	Tube V1 defective in chopper.	a.	Replace.
		b.	Chopper inoperative.	b.	Replace chopper.
12.	NULL adjustment impossible.	a.	Fuse F2 blown.	a.	Replace.
		b.	Defective V101, V102, V103, V104, V105, V108, V109 and V110.	b.	Replace.
13.	High ripple.	a.	External control resistor and control line are coupling stray ac signal to unit.	a.	Shield control and/or line.
		b.	Defective V103, V104, V105, or V107 and V108.	b.	Replace.
		c.	Defective C1, C2, C3, C4, C5, C7, C8, C9 and C201 thru C205.	c.	Replace.
14.	DC changes abruptly at a periodic rate.	a.	Defective V101, V102, V103, V104, V105, or V109, V110.	a.	Replace. Recalibrate if V105 is replaced.


REVISIONS
REV. E DESCRIPTION: REV PER ECO NO 0433 DATE: 11 20 62 BY: RJ
K1 TDR
T1 5091
CR1 CR3 CR4 CR5 CR6 CR7 CR8 CR9
CR10 CR11 CR12 CR13 CR14 CR15 CR16 CR19
MOT
6 A
F2
C11 C12 C13 C14 C15 120 450V
R30 R31 R32 R33 R34 82K,2W
T4 5234
T2 5092
T3 5090
V201 - V212 6DQ6-8
SERIES SINK
R254 1M
C206 C207 C208 220uuf 3KV
R201 47 1W
R224 82 1W
R212 4.7 1W
R213 82 1W
R225 470 1W
R236 470 1W
R40 15K
R41 2.7K
R237 2.2K 1W
R248 2.2K 1W
V201 THRU V212 12 TUBES 2 GROUPS 6 EA
F1 15AMP
S1 LINE
(17) PC BD.
(7) PC BD.
DS1 LINE ON
FAN B1
105-125 VRMS 50-60~
CR21 CR22 CR23 CR24 CR25 CR26 CR27 CR28
C5 120 450V
C3 40 450V
C4 8 450V
R38 R39 50K 50W
R8 10K,20W
R101 5.1K 1W
CR101
R103 1M
V106 12AX7
R102 5M
V101 0A2
V102 0B2
R104 R105 250K 5WDF
C101 220UUF 3000V
V103 0A2
V104 0B2
V105 85A2
R106 390K
R107 1M
CR102
R17 5K 10W
R112 3.6K 1W
R108 5.6K,1W
C103 100 UUF 500V
R109 330K
V107 6842
C102 220UUF 500V
R110 220K
R111 100K
R114 330K
CR103 IN2009
V108 12AX7
SEE NOTE 6
R115 120K 1W
R116 3K WW ±2%
R117 76K 3W ±1%
R118 220K
V112 ARG4
V111 ARG4
J101
C10 25,25V
R20 3K NULL
R10 10K 2W WW CAL
REFERENCE & AMPLIFIER 355-C-5
T8 2
REM
E4
+
GND
E5
-
E6
REM
R301 300K ±1% 1W WW
R302 300K ±1% 1W WW
R303 300K ±1% 1W WW
R304 300K ±1% 1W WW
300
600
900
1200
0
S301 STEP SWITCH
COARSE
R18 300K 6W ±2%
FINE
R9 10K 3W WW
M1 MA 0-100 SEE NOTE 2
C9 0.5 2000V
R6 20, 1W
TP1 (BLK)
S2
K2
DC
DS2 R DC ON
M2 0-1500 SEE NOTE 2
R7 1.5M ±1% 1W
R11 25 25W WW
R2 25 25W WW
C201 C202 C203 C204 C205 120 450V
R249 R250 R251 R252 R253 82K 2W
P/O SERIES SINK
E1 +
E2 GND
E3 -
FILAMENT REGULATOR 349-A-67
R705 3K
R704 3.3K
Q703 2N1372
Q702 2N1372
Q701 EM101
R706 220
R702 18K
R703 3.6K
C702 1 50V
CR702
C701 1000 15V
R701 560
CR701
R708 5 3W
R707 5 3W
R42 3K
LIMITER MA
R606 33K MAX CAL NOTE 5
ZERO ADJ R602 100
Q601
R601 470K
R603 1K
Q602 (2) 2N398
C601 .022 200V
R605 330K
R608 330K
R609 270K
R604 100K
CR601
R607 68K
LIMITER 349-B-72
1 UNLESS OTHERWISE SPECIFIED: ALL RESISTANCE VALUES IN OHMS, ALL RESISTORS ARE 1/2 WATT. K=1,000 OHMS - M=1,000,000 OHMS. ALL CAPACITANCE VALUES IN MICROFARADS.
2 SUPPLIED ON METERED UNITS ONLY.
3 DENOTES EQUIPMENT MARKING ON FRONT PANEL.
4 DENOTES SCREWDRIVER ADJUSTMENT ON FRONT PANEL.
5 R24 IS SELECTED FOR CALIBRATION OF LIMITER DIAL (ABOUT 200K)
6 JUMPER IS REMOVED FOR CHOPPER STABILIZER UNIT, J101 IS INSTALLED AND V108 BECOMES A 12AY7.
REVISIONS
D REV PER ECO NO 0561 7-2-62 EC
C REV PER ECO NO 0353 6-21-62 EC
B REV PER ECO 0306 3-9-62 EC
A REV PER ECO 0270 1-17-62 EC
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CONSTANT VOLTAGE
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ELECTRONIC MEASUREMENTS
DWG NO 355-D-31 E

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